Nematic-crystal phase separations in liquid crystal colloids(Poster session 2, New Frontiers in Colloidal Physics : A Bridge between Micro- and Macroscopic Concepts in Soft Matter)

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コロイド粒子は濃度の増加につれて液体相から結晶相へ相転移する。このようなコロイド粒子を液晶分子溶媒と混ぜるとどのような相分離が可能であるか [1]？ここでは液晶分子はネマチック相ー等方相の相転移を起こすとする。この様な液晶コロイド系では，コロイド粒子の結晶化と液晶分子のネマチック相転移が競合した新しい相分離が可能である。液晶分子のネマチック相の秩序パラメーターと，コロイド粒子の Fcc や Bcc などの結晶構造を示す結晶化の秩序パラメーター [2] を考慮した自由エネルギーを構築し，温度，濃度や外場（電場や磁場）によってどのような相分離が可能であるかを調べる。このような液晶コロイド系の相分離は，液晶化と結晶化が競合した新しい相分離ダイナミクスによって進行していく。

It is well known that there is co-existence of liquid and crystal phases in solutions of hard spherical colloids. How these colloids take place phase separations when they are dispersed in a nematic liquid crystalline solvent? Some experiments have shown that a mixture of a colloidal particle and a liquid crystal solvent (liquid crystal-colloid) has a variety of phase separations[1]. In liquid crystal-colloid mixtures, the phase separation is induced by the co-occurence between orientational ordering of the liquid crystal and crystalline ordering of the colloid. In this paper we present a simple mean field model to describe phase separations in liquid crystal-colloid mixtures. We take into account an orientational order parameter of a nematogen (solvent) and a translational order parameter of colloids to describe a Fcc or Bcc crystalline phase[2].

Figure 1 shows some results of the phase diagrams for $n_c = 3$, $n_r = 2$, α_c=0.1, and α_n=5. The value of an anchoring strength α_a is changed: (a) α_a=0, (b) α_a=0.75. The temperature is normalized by the nematic-isotropic transition temperature T_{NI} of a pure nematogen. The solid curve shows the binodal and the dotted curve corresponds to the phase transition lines. The dash-dotted line shows the spinodal. When $\alpha_a = 0$ (Fig. 1(a)), or there is no anchornig energy, we have a nematic-isotropic (N+I) phase separation below T_{NI}, which has been well known in polymer-liquid crystal mixtures. The nematic phase of the lower concentration consist of almost pure nematogens and the isotropic phase of the higher concentration contains colloids and nematogens. We also have a phase separation between isotropic and crystalline phases (I+C)

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at high concentrations and the triple point (N+I+C) where two isotropic liquid phases and a crystalline phase can simultaneously coexist at $\tau = 0.844$. The crystalline phase (C) shows a colloidal crystalline phase dispersed in isotropic nematogens. Below the triple point we have the two-phase coexistence between a nematic and a crystalline phase (N+C). Inside the binodal line we have three different metastabe regions: an isotropic metastable (Im); a crystalline metastable (Cm); nematic metastable (Nm). We also have a nematic unstable region (Nu). On increasing the anchoring energy (α_a) between colloids and nematogens, the phase behavior is drastically changed. When $\alpha_a = 0.75$ (Fig. 1(b)), we have a stable NC region, where colloidal particles dissolved in a nematic phase form a crystalline structure.

We will discuss phase separations, depending on the strength of anchoring between colloid and nematic solvents.

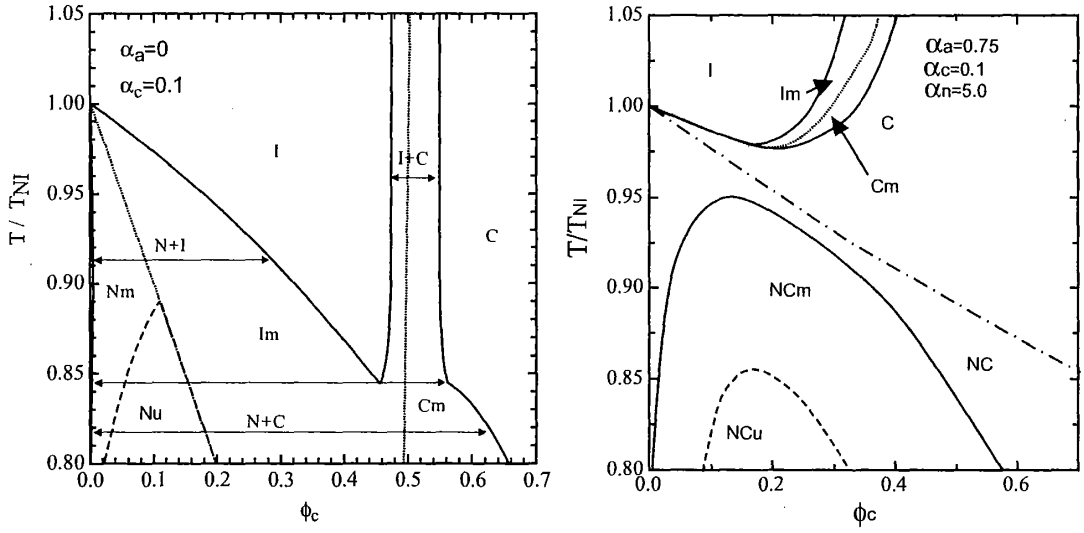

Figure 1: Phase diagram on the temperature (T/T_{NI})-volume fraction (ϕ_c) plane in a liquid crystal-colloid mixture: isotropic (I), Nematic (N), and crystalline (C) phase.

References

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